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ABSTRACT

An analysis was conducted of two large samples of 13- and 17-year-old students (N=7,928) who were assessed by the National Assessment of Educational Progress during the 1977-78 and 1981-82 mathematics assessments. A group of 18 statements about math were used to construct a math attitude index. A multivariate log-linear analysis included gender, assessment year, and age as independent variables and the math attitude index as the dependent variable. The results revealed that all three independent variables made significant contributions to the final model. A five-way analysis of variance was done using the dependent variable of math achievement score and the independent variables of math attitude index, race, gender, type of community, and racial composition of the school. The results of this analysis showed that math achievement was significantly affected by each of the independent variables. There were also three significant two-way interactions identified: (1) type of community and racial composition of the school; (2) math attitude index and racial composition of the school; and (3) math attitude index and gender. These findings suggest that while gender differences do exist in both attitudes toward math and achievement in math, these differences are less than the differences in the other variables examined. Additional multivariate studies should be done to examine this issue further. (Author/NB)

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# Gender Differences in Mathematics Attitudes and Achievement

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ABSTRACT

An analysis of two large samples of 13-year-old and 17-year-old students assessed by the National Assessment of Education Progress during the 1977-78 and 1981-82 mathematics assessments.

A group of 18 statements about math were used to construct a math attitude index. A multivariate log-linear analysis included gender, assessment year, and age as independent variables and the math attitude index as the dependent variable. All three independent variables made significant contributions to the final model.

A five-way analysis of variance was then done using math achievement score as the dependent variable and the following as independent variables: math attitude index, race, gender, type of community, and racial composition of the school. Math achievement was significantly affected by each of the independent variables. There were also three significant two-way interactions identified. The first was type af community and racial composition of the school. The second was math attitude index and racial composition of the school. The third was math attitude index and gender.

Conclusions were that while gender differences do exist in both attitudes toward math and achievement in math, these differences are less than the differences in the other variables examined. It was recommended that additional multivariate studies be done.

CONTENTS


page

1. INTRODUCTION . . . . . 1

The Data . . . . . 4
Description of Population . . . . . 11

2. ATTITUDES TOWARD MATHEMATICS . . . . . 12

3. MATHEMATICS ACHIEVEMENT . . . . . 32

REFERENCES . . . . . 43

LIST OF TABLES


| Table | | page |
|---|---|---|
| 1. | Source of NAEP Data on Attitudes Toward Mathematics and Mathematics Achievement | 4 |
| 2. | Basic Population Demographics | 11 |
| 3. | Chi-Square Analyses of Individual Attitude Items | 14 |
| 4. | Bivariate Distribution on Positive Math Attitude Index | 15 |
| 5. | Multivariate Distribution of Positive Math Attitude Index | 15 |
| 6. | Multivariate Model of Positive Math Attitude Index, Gender, Age, and Year | 16 |
| 7. | Significant Relationships Between Positive Math Attitude Index, Gender, Age, and Year | 18 |
| 8. | Factor Structure of Mathematics Attitude Items | 20 |
| 9. | Multivariate Distribution of Math and Oneself Factor | 21 |
| 10. | Multivariate Model of Math and Oneself Factor, Gender, Age, and Year | 22 |
| 11. | Significant Relationships Between Math and Oneself Factor, Gender, Age, and Year | 23 |
| 12. | Multivariate Distribution of Math as a Discipline Factor | 24 |
| 13. | Multivariate Model of Math as a Discipline Factor, Gender, Age, and Year | 25 |
| 14. | Significant Relationships Between Math as a Discipline Factor, Gender, Age, and Year | 26 |

15. Multivariate Distribution of Math as a Process Factor . . . . . 27

16. Multivariate Model of Math as a Process Factor, Gender, Age, and Year . . . . . 28

17. Significant Relationships Between Math as a Process Factor, Gender, Age, and Year . . . . . 28

18. Multivariate Distribution of Math in Daily Life Factor . . . . . 29

19. Multivariate Model of Math in Daily Life Factor, Gender, Age, and Year . . . . . 30

20. Significant Relationships Between Math in Daily Life Factor, Gender, Age, and Year . . . . . 31

21. Mean Percentile Ranking on Math Achievement for Main Effects . . . . . 35

22. Analysis of Variance for Math Achievement . . . . . 36

23. Mean Percentile Ranking on Math Achievement for Interaction Effects . . . . . 38

23. Mean Percentile Ranking on Math Achievement for Interaction Effects . . . . . 39

23. Mean Percentile Ranking on Math Achievement for Interaction Effects . . . . . 40

# 1. INTRODUCTION

There are increasing demands on schools today to produce students who are literate. As the technological revolution continues, there is an increased emphasis on mathematics and science. The area of gender differences in these subjects has been explored for many years. Many people feel that there are significant gender differences in both attitudes toward, and achievement in, these subjects.

It the purpose of this paper to examine some of the attitudes toward mathematics and achievement in mathematics and to explore the relationships between them, and between other types of influences. These other influences include those of community, school, and home, as well as gender, age and year.

A report on participation and achievement of women in mathematics by Armstrong (1985), opens with the following statement:

> It is generally accepted that elementary school girls excel in arithmetic and science. However, the picture begins to change in junior high school as boys overtake and pass their female contemporaries in mathematics achievement. From the eighth grade on, female participation in mathematics declines steadily until, by high school graduation, male students outnumber women in mathematics classes. (pp. 59-60)

National Assessment of Educational Progress reports have confirmed the fact that there are significant gender differences in achievement on mathematics assessments begin-

ning at puberty and continuing through adult life, with males generally having superior scores (NAEP, 1978, 1979).

A contributing factor may be sex-role stereotyping. Previous research has shown that women who anticipate a conflict between a career and the traditional role of homemaking are more likely to opt for the traditional role. Mathematics has long been considered a male domain (Astin, 1974; Rossi, 1965).

An individual's attitude toward mathematics is a combination of that individual's enjoyment, confidence, and anxiety toward mathematics (Armstrong, 1985).

Parental influence also affects an individual's attitudes and achievement, although the exact nature of the influence is not clear from the research. Another source of influence on attitudes and achievement in mathematics is that from peers, teachers, and counselors at school. Unfortunately, teachers often treat males and females differently in mathematics classes.

In a study of fourth grade mathematics Peterson and Fennema (1985) concluded that girls and boys did not differ significantly in mathematics achievement. They did find, however, that activities within the classroom may have different influences on girls' and boys' learning of math.

The impact of the popular press reports on parents' attitudes toward their children's abilities and performance in

mathematics was studied by Jacobs and Eccles (1985). The pattern they discovered was that parents exposed to popular mass media reports about mathematics research appeared to change attitudes slightly more than those not exposed to the mass media reports. Fathers' beliefs about the mathematical ability of their children and their stereotypes about gender differences in ability became more similar for males and females. On the other hand, mothers who were exposed became more differentiated on their beliefs and stereotypes, depending on the gender of the child. Mothers of females became much more conscious of gender differences after hearing the research findings.

A follow-up study by Benbow and Stanley (1982) of their Study of Mathematically Precocious Youth established that the gender differences in mathematical reasoning ability persisted over several years. They also found few significant gender differences in mathematics attitudes. One must remember that this study includes only students who are mathematically gifted and highly motivated, and that it is based on self-reported data. It was their conclusion that in the intellectually, rather homogeneous group studied, mathematical reasoning ability was a better predictor of mathematics achievement than were attitudes toward mathematics.

A path analysis study of females enrolled in advanced placement mathematics courses by Casserly and Rock (no date), showed that "positive attitudes towards women's roles and occupational stereotypes depend on the attitudes and education of the mother, rather than the father" (p. 279). They also found that encouragement from mathematics teachers had a positive effect on females.

## THE DATA

The population in this study consisted of 13-year-old and 17-year-old students assessed by the National Assessment of Educational Progress (NAEP) as part of the 1977-78 and 1981-82 mathematics assessments. It was a national probability sample of 7,928 students. The distribution within each age group and assessment year is shown in Table 1.

TABLE 1

Source of NAEP Data on Attitudes Toward Mathematics and Mathematics Achievement

| Year | Age | N |
|---|---|---|
| 1977-78 | 13-year-olds | 2,060 |
| | 17-year-olds | 2,101 |
| 1981-82 | 13-year olds | 1,797 |
| | 17-year-olds | 1,969 |
| Total | | 7,928 |

Since the first assessment in 1969-70, the National Assessment of Educational Progress (NAEP) has collected one of the most extensive data sets in the history of educational research. It provides a national probability survey of knowledge, skills, understanding, and attitudes of three age levels--9-, 13-, and 17-year-olds--in 10 different subject areas along with a wide variety of demographic information. From the point of view of the analyst, most of the individual items are of little interest per se, but are of interest when they are combined into scales and indices that represent broader constructs important to various analytic questions.

The idea of a national assessment began in the early 1960s with the thoughts of Francis Keppel, John Gardner, and others, as they speculated about the needs of education in this country and the criticisms that were being leveled against it.

Accurate information about what and how children are learning is essential for wise decision-making in education. However, information alone does not change education. What is needed is wise use of this information by those who can change education.

NAEP is an on-going project whose ultimate goal is the measurement of change in knowledge, skills, understandings, and attitudes related to educational experiences and objectives and, therefore, requires repeated measurements.

NAEP uses a deeply stratified three-stage national probability sample design with oversampling of low-income and rural areas. Primary sampling units are counties or groups of counties meeting minimum size requirements. These are stratified by region and size of community. Public and private schools are randomly selected in the second stage of sampling, and individuals are randomly selected in the third stage. The selection probability of each individual is computed and its reciprocal, adjusted for nonresponse, is used to weight each response in all statistical calculations.

NAEP data provide a continuing survey of the knowledge, skills, understandings, and attitudes of young Americans in 10 subject areas. The first assessments were conducted in 1969-70. Assessments were conducted annually through 1979-80 and, due to budget constraints, biennially since that time.

The development of an assessment in a learning area evolves from a consensus process that takes several years of work by educators, measurement specialists, and lay persons from all over the nation (Wright, Larsson, & Ramlow, 1981). The process begins with the development of objectives for the learning area. These objectives state the general goals it is felt young people should achieve in the course of their education. The objectives are then reviewed by the subject matter specialists, the measurement experts, and the lay people, and revised as necessary. When completed they

are given to writers whose task is to create exercises appropriate to measure the objectives.

The exercises are then divided into booklets for administration. The average booklet takes approximately 45 minutes to complete. Each is given to deeply stratified multistage probability samples of the appropriate age group, 9-, 13-, or 17-year-olds. Open-ended exercises are scored by hand, while multiple-choice and true-false exercises are machine scored. The higher-level data on school and community information are then added to each respondent record, using common labels for background and demographic variables that extend across assessment years (Wright, Larsson, & Ramlow, 1981).

After consistency checks, the data are then stored in complex hierarchical files along with corresponding documentation. Both data and documentation are compatible with major statistical booklets such as Statistical Analysis Systems (SAS) and Statistical Packages for the Social Sciences (SPSS). All data files are rectangular and numeric with uniform codes for "I don't know," "no response," and "missing value." These machine-readable data and documentation are then made available for public use (Wright, Larsson, & Ramlow, 1981).

Shortly after the beginning of NAEP assessments, VonHaden and King (1971) discussed some of the implications of a

national assessment. It was their opinion that, while a national assessment will not cure many of the educational ills, it will be a valuable tool to aid education in solving some of its perplexing problems. One of the strengths of NAEP data are that they reveal what individual students have learned as well as what various groups (regions, socioeconomic groups, types of communities, gender, age, etc.) have learned. NAEP assessments also will provide information for comparing progress in education over a period of years.

Mosteller and Moynihan (1972), in an article appearing in a volume dealing with reanalysis of Coleman's Equality of Educational Opportunity Study, stated:

> At regular intervals the nation should measure the state of the schools, its students and teachers, with a view to appraising progress toward its goals . . . The National Assessment of Educational Progress of the Educational Commission of the States gives us the first appraisal of what this country's school children and young adults know and can do. (p. 55)

It was their opinion that as reassessments took place it would be possible to analyze the changes in amounts and kinds of knowledges, skills, understandings, and attitudes.

In the same volume, Dyer (1972) noted that the sampling plan of NAEP deliberately avoids the possibility of providing descriptive indices for state and local school systems, but instead provides a set of educational indices for the nation as a whole and for various combinations of subgroups at each age level. From these data it might be possible to

develop some indices to discern trends in pupil performance, and this is a problem for future analysts. The groundwork for further in-depth analyses has been laid.

The National Assessment of Educational Progress is collecting valuable data on a national level about the achievement of students at three age levels in 10 different subject areas. While the purpose of NAEP is to examine achievement and attitudes on individual exercise items and individual objectives within each subject and assessment year, it is possible to do cross-year analyses. NAEP data can provide information to help solve some of the problems in education today. It can also provide information on the changes in achievement in each of the subject areas over time.

NAEP can help provide answers on how to measure equality of educational opportunity by providing not only information on what young people do and do not know in each subject area, but also sociological information which will allow comparisons of young people from various subgroups. It can provide valuable benchmarks against which future educational change can be measured (Forbes, 1976).

NAEP data provide a powerful source for secondary analysis, although secondary analysis is more complex and demanding than it often appears to the uninitiated. From the perspective of the analyst, the most difficult problem is not the structure of the data or its volume, but the structure of the documentation (Anderson, Welch, & Harris, 1980).

However, many of these problems have been alleviated by work done at the Public Opinion Laboratory at Northern Illinois University. The staff there has developed a system of simplifying the documentation and merging the individual booklet data files for secondary analysis (McConeghy & Miller, 1983).

During the past decade and a half, the various revelations of NAEP assessments have helped to make education more "newsworthy" (Bailey, 1981). The assessment programs of NAEP now make it possible for national comparisons to be made over time (Chall, 1983).

Because of the types of background information collected it is possible to do correlational studies relating home, community, school, and individual respondent characteristics to the achievement of specific objectives. The earlier data collected by NAEP did not provide as much background information as was needed to do effective studies of this kind. However, beginning with the 1975-76 assessment, this aspect has been strengthened to allow more in-depth analyses. Secondary analyses of NAEP data are becoming more prevalent as documentation is improved and background variables become standardized. These improvements, coupled with the advances made in multivariate categorical data analysis, make NAEP data an excellent source of meaningful, large-scale, national probability multivariate analyses that can determine ex-

isting relationships and provide a sound basis for the improvement of teacher training and in-service training of existing teachers.

## DESCRIPTION OF POPULATION

The analysis included a total on 7,928 students. This group was evenly distributed between males and females (see Table 2). There were slightly more students assessed in 1977-78 than in 1981-82. There were also more 17-year-olds assessed.

TABLE 2

Basic Population Demographics

| Group | % | N |
|---|---|---|
| Gender | | |
| Male | 50% | 3,985 |
| Female | 50 | 3,943 |
| Assessment Year | | |
| 1977-78 | 53 | 4,162 |
| 1981-82 | 47 | 3,766 |
| Age | | |
| 13-year-olds | 49 | 3,858 |
| 17-year-olds | 51 | 4,070 |

## 2. ATTITUDES TOWARD MATHEMATICS

There were 18 statements included in the math attitude question in the assessment. Each respondent was asked to indicate his or her level of agreement with each of the following statements about math:

A. I am willing to work hard to do well in math.

B. Math is more for girls than for boys.

C. Learning math is mostly memorizing.

D. Math is useful in solving everyday problems.

E. Exploring number patterns plays no part in math.

F. I enjoy mathematics.

G. There is always a rule to follow in solving math.

H. Most of math has practical use.

I. Knowing how to solve is as important as solution.

J. Math requires practice in following rules.

K. A person can get along well without using math.

L. Mathematicians work with symbols-not ideas.

M. Fewer men than women have logical ability.

N. Knowing why an answer is correct is as important as the correct answer.

O. Math is made up of unrelated topics.

P. I really want to do well in mathematics.

Q. My parents really want me to do well in math.

R. I feel good when I solve a math problem alone.

The response options were: strongly disagree, disagree, undecided, agree, or strongly agree. There was less than one percent non-response on each of these items.

A traditional bivariate cross-tabulation analysis was done on each of the items using first gender, then age, and finally, year as independent variables. All but three of these analyses showed statistically significant differences at or beyond the .05 level. These 54 analyses are summarized in Table 3.

A Positive Math Attitude Index (PMAI) was then created. Those who responded with a positive response to 14 or more of the 18 statements were classified as "high" on the PMAI. Those who responded with a positive response to 12 or 13 of the statements were classified as "moderate" on the PMAI. Those who responded with a positive response to 11 or fewer of the statements were classified as "low" on the PMAI.

The bivariate distribution on the Positive Math Attitudes Index is shown in Table 4. These bivariate relationships are suggestive of significant differences. However, these differences can only be confirmed by multivariate analysis, as individual respondents reflect combinations of these independent variables. It is essential to examine the multivariate distributions to see if there are significant interaction effects. The multivariate distribution is shown in Table 5.

TABLE 3

Chi-Square Analyses of Individual Attitude Items

| | Gender | | Age | | Year | |
|---|---|---|---|---|---|---|
| Item | $X^2$ | sign. | $X^2$ | sign. | $X^2$ | sign. |
| A | 68.97 | ** | 380.96 | ** | 37.70 | ** |
| B | 159.62 | ** | 53.28 | ** | 52.25 | ** |
| C | 26.98 | ** | 61.21 | ** | 30.22 | ** |
| D | 15.29 | ** | 17.29 | ** | 51.50 | ** |
| E | 53.46 | ** | 28.06 | ** | 20.05 | ** |
| F | 10.62 | 0.06 | 195.49 | ** | 35.34 | ** |
| G | 18.28 | ** | 34.76 | ** | 16.78 | ** |
| H | 20.44 | ** | 88.23 | ** | 27.78 | ** |
| I | 24.68 | ** | 50.53 | ** | 22.58 | ** |
| J | 53.01 | ** | 62.13 | ** | 14.86 | ** |
| K | 32.75 | ** | 168.23 | ** | 26.95 | ** |
| L | 29.10 | ** | 99.20 | ** | 6.91 | 0.23 |
| M | 24.86 | ** | 154.88 | ** | 66.46 | ** |
| N | 73.79 | ** | 76.43 | ** | 21.29 | ** |
| O | 59.13 | ** | 74.22 | ** | 5.83 | 0.32 |
| P | 31.54 | ** | 528.29 | ** | 34.22 | ** |
| Q | 25.41 | ** | 579.77 | ** | 14.84 | ** |
| R | 189.17 | ** | 14.00 | 0.02 | 25.27 | ** |

** = $p < .01$

TABLE 4

Bivariate Distribution on Positive Math Attitude Index

| | Positive Math Attitude Index | | | |
|---|---|---|---|---|
| | Low | Moderate | High | N |
| Total | 37% | 33% | 31% | 7928 |
| Gender | | | | |
| Male | 40 | 31 | 29 | 3986 |
| Female | 34 | 34 | 32 | 3944 |
| Age | | | | |
| 13 years old | 36 | 34 | 30 | 3858 |
| 17 years old | 37 | 31 | 31 | 4070 |
| Year | | | | |
| 1977-78 | 38 | 33 | 29 | 4162 |
| 1981-82 | 35 | 33 | 32 | 3766 |

TABLE 5

Multivariate Distribution of Positive Math Attitude Index

| | | | Positive Math Attitude Index | | | |
|---|---|---|---|---|---|---|
| Year | Age | Gender | Low | Moderate | High | N |
| 77-78 | 13 | Male | 40.8% | 33.5% | 25.7% | 1060 |
| | | Female | 35.4 | 36.1 | 28.6 | 1001 |
| | 17 | Male | 40.8 | 29.7 | 29.5 | 1033 |
| | | Female | 36.4 | 31.7 | 31.8 | 1068 |
| 81-82 | 13 | Male | 36.9 | 32.0 | 31.1 | 935 |
| | | Female | 30.9 | 34.1 | 35.0 | 862 |
| | 17 | Male | 39.2 | 29.0 | 31.7 | 958 |
| | | Female | 33.5 | 35.4 | 31.1 | 1011 |

A multivariate logit analysis was then done using PMAI as the dependent variable and gender, age, and year as independent variables. The results of this analysis are displayed in Table 6.

TABLE 6

Multivariate Model of Positive Math Attitude Index, Gender, Age, and Year

| Model | Terms | d.f. | L.R.$X^2$ | CMPD |
|---|---|---|---|---|
| H1 | GAY,M. | 14 | 53.42 | -- |
| H2 | GAY,MG,MY,MA. | 8 | 11.14 | .791 |
| H3 | Difference due to MG. | 2 | 24.75 | .463 |
| H4 | Difference due to MY. | 2 | 12.23 | .229 |
| H5 | Difference due to MA. | 2 | 5.72 | .107 |
| H6 | Difference due to MAY. | 2 | 6.88 | .129 |
| H7 | GAY,MG,MY,MA,MAY. | 6 | 4.25 | .920 |

Legend:
M = Positive Math Attitude Index.
G = Gender.
A = Age.
Y = Year of assessment.
d.f. = Degrees of Freedom.
L.R.$X^2$ = Likelihood-Ratio Chi-Square.
CMPD = Coefficient of Multiple-Partial Determination.

For those not familiar with Goodman's (1972a, 1972b) log-linear technique, model H1 is referred to as the independence model. It provides an estimate of the total mutual dependence in the model, that is, the total error in a pro-

portional-reduction-of-error sense. The Likelihood Ratio chi-square (L.R.$X^2$) is utilized as a measure rather than the Pearson chi-square because the former is additive while the latter is not. The Coefficient of Multiple-Partial Determination (CMPD) is a measure of the proportional-reduction-of-error and is roughly analogous to the multiple $R^2$ in quantitative regression models.

Model H2 in Table 6 is referred to as the main effects model and it provides an estimate of the improvement in prediction based on the direct effect of each of the independent variables on the dependent variable. By deleting each of these main effects one at a time, it is possible to determine the relative contribution of each main effect. For example, Model H3 is the same as Model H2 except that the MG term (the direct effect of gender on PMAI) has been deleted. Thus, it is possible to determine by subtraction, that gender accounted for slightly more than 46% of the mutual dependence in the model, and was the strongest main effect (see Table 6).

Next, the standardized values (S.V.) of Goodman's lambda were examined to determine the direction of these effects in the final model. They are shown in Table 7. These standardized values have the same interpretation as a z-score and are significant at the .05 level with a value of 1.96 or greater.

TABLE 7

Significant Relationships Between Positive Math Attitude Index, Gender, Age, and Year

| | | Positive Math Attitude Index | | | |
|---|---|---|---|---|---|
| | | Low | Moderate | High | N |
| Gender | | | | | |
| Male | | 4.93 | -2.89 | -1.87 | 3986 |
| Female | | -4.93 | 2.89 | 1.87 | 3942 |
| Year of Assessment | | | | | |
| 1977-1978 | | 3.05 | n.s. | -3.16 | 4162 |
| 1981-1982 | | -3.05 | n.s. | 3.16 | 3766 |
| Age | | | | | |
| 13-year-olds | | n.s. | 2.36 | n.s. | 3858 |
| 17-year-olds | | n.s. | -2.36 | n.s. | 4070 |
| Year | Age | | | | |
| 1977-1978 | 13 | n.s. | n.s. | -2.61 | 2061 |
| | 17 | n.s. | n.s. | 2.61 | 2101 |
| 1981-1982 | 13 | n.s. | n.s. | -2.61 | 1797 |
| | 17 | n.s. | n.s. | 2.61 | 1969 |

Examination of these Standardized Values presented in Table 7 was then done to allow conclusions to be made about the directionality of the ratings on the PMAI among the independent variable categories. All three of the independent variables had a direct influence on the PMAI. Females were more likely than males to have a "moderate" or "high" rating on the PMAI. Students in 1981-1982 were more likely to be rated "high" on the PMAI than were students in 1977-1978. Students at age 13 were more likely than students at age 17 to be rated "moderate" on the PMAI.

The interaction between age and year of assessment showed that 17-year-olds were more likely to be rated "high" on the PMAI in 1977-1978, while 13-year-olds were more likely to be so rated in 1981-1982.

A factor analysis was then performed using these 18 attitude items. Four factors were identified. Since it was important to use statistical procedures which were consistent not only with the nature of the data, but also with the construct being measured, the factor analysis was done using the ordinal correlation coefficient gamma. The oblique rotations of the extracted factors were used to identify the dimension which was maximally correlated with the given set of items (Miller, Suchner, & Voelker, 1980). The results of this factor analysis are presented in Table 8.

A multivariate logit analysis was then done for each of these four factors using the factor as the dependent variable, and gender, age, and year as the independent variables. The multivariate distribution on the first factor, "Math and Oneself," is shown in Table 9. The items included in this factor were:

I really want to do well in mathematics.

I am willing to work hard to do well in math.

I feel good when I solve a math problem alone.

I enjoy mathematics.

My parents really want me to do well in math.

TABLE 8

Factor Structure of Mathematics Attitude Items

| | FACTOR 1 | FACTOR 2 | FACTOR 3 | FACTOR 4 |
|---|---|---|---|---|
| **Mathematics and Oneself** | | | | |
| Really want to do well in mathematics. | .97314 | -.24120 | .28659 | .42554 |
| Willing to work hard to do well in math. | .80703 | -.26335 | .16588 | .46526 |
| Parents really want me to do well in math. | .67664 | -.25975 | .40642 | .33058 |
| Enjoy mathematics. | .61977 | -.21888 | .03485 | .47100 |
| Good when I solve a math problem alone. | .58877 | -.06485 | .33922 | .25873 |
| **Mathematics as a Discipline** | | | | |
| Fewer men than women have logical ability. | -.12696 | .69009 | -.06753 | -.20452 |
| Math is more for girls than for boys. | -.29105 | .56309 | -.16331 | -.27235 |
| Math is made up of unrelated topics. | -.14902 | .49529 | -.00913 | -.26756 |
| Exploring number patterns plays no part. | -.15474 | .36375 | -.17419 | -.29782 |
| Mathematicians work with symbols-not ideas | -.08490 | .36055 | .12685 | -.10279 |
| Learning math is mostly memorizing. | -.01072 | .33312 | .25211 | -.04071 |
| **Mathematics as a Process** | | | | |
| Always a rule to follow in solving math. | .31587 | -.02325 | .61768 | .31449 |
| Math requires practice in following rules. | .26399 | -.00839 | .60072 | .20507 |
| Know how to solve important as solution. | .41275 | -.44269 | .49697 | .45288 |
| Know why ans correct important as answer. | .39953 | -.47513 | .49249 | .35675 |
| **Mathematics and Daily Life** | | | | |
| Math useful in solving everyday problems. | .28326 | -.23083 | .19528 | .72018 |
| Most of math has practical use. | .39178 | -.23345 | .24270 | .64593 |
| Can get along well without using math. | -.44583 | .31010 | -.15470 | -.63100 |

Those who responded "strongly agree" or "agree" to four of these five statements were classified as "high" on the Mathematics and Oneself factor. All others were classified as "low."

TABLE 9

Multivariate Distribution of Math and Oneself Factor

| | | | Math and Oneself | | |
|---|---|---|---|---|---|
| Year | Age | Gender | Low | High | N |
| 77-78 | 13 | Male | 41.2% | 58.8% | 1059 |
| | | Female | 38.9 | 61.1 | 1001 |
| | 17 | Male | 57.8 | 42.2 | 1032 |
| | | Female | 57.0 | 43.0 | 1069 |
| 81-82 | 13 | Male | 44.4 | 55.6 | 936 |
| | | Female | 36.1 | 63.9 | 862 |
| | 17 | Male | 57.3 | 42.7 | 958 |
| | | Female | 53.4 | 46.6 | 1011 |

The results of the logit analysis are presented in Table 10. The strongest relationship was that between age and the Math and Oneself Factor. It accounted for almost 93% of the variation in the model. Gender accounted for almost 5% of the variation, and was the second significant term retained in the final model. There were no significant interaction effects noted. The final model included the direct effects of age and gender, and accounted for move 96% of the

variation in the independence, which provided an excellent fit to the data (see Model H6 in Table 10).

TABLE 10

Multivariate Model of Math and Oneself Factor, Gender, Age, and Year

| Model | Terms | d.f. | L.R.$X^2$ | CMPD |
|---|---|---|---|---|
| H1 | GAY,M. | 7 | 227.06 | -- |
| H2 | GAY,MA,MG,MY. | 4 | 7.45 | .967 |
| H3 | Difference due to MA. | 1 | 210.97 | .929 |
| H4 | Difference due to MG. | 1 | 11.15 | .049 |
| H5 | Difference due to MY. | 1 | 0.65 | .003 |
| H6 | GAY,MA,MG. | 5 | 8.10 | .964 |

Legend:
M = Math and Oneself Factor.
G = Gender.
A = Age.
Y = Year of assessment.
d.f. = Degrees of Freedom.
L.R.$X^2$ = Likelihood-Ratio Chi-Square.
CMPD = Coefficient of Multiple-Partial Determination.

The Standardized Values for this factor are presented in Table 11. Students who were 13-years-old were more likely to be ranked "high" on the Math and Oneself factor than were students who were 17-years-old. Females were more likely than males to be ranked "high" on this factor.

TABLE 11

Significant Relationships Between Math and Oneself Factor, Gender, Age, and Year

| | Math and Oneself | | |
|---|---|---|---|
| | Low | High | N |
| Age | | | |
| 13-year-olds | -14.41 | 14.41 | 3858 |
| 17-year-olds | 14.41 | -14.41 | 4070 |
| Gender | | | |
| Male | 3.34 | -3.34 | 3986 |
| Female | -3.34 | 3.34 | 3942 |

The second factor analyzed was that of Math as a Discipline. The multivariate distribution is shown in Table 12. The items included in this factor were:

Fewer men than women have logical ability.

Math is more for girls than for boys.

Math is made up of unrelated topics.

Learning math is mostly memorizing.

Mathematicians work with symbols-not ideas.

Exploring number patterns plays no part in math.

Students who responded "strongly disagree" or "disagree" to three of the six statements were classified as "high" on this factor. All others were classified as "low."

The logit analysis for the Math as a Discipline factor is shown in Table 13. The strongest relationship was,

TABLE 12

Multivariate Distribution of Math as a Discipline Factor

| Year | Age | Gender | Math as a Discipline: Low | Math as a Discipline: High | N |
|---|---|---|---|---|---|
| 77-78 | 13 | Male | 61.1% | 38.9% | 1059 |
| | | Female | 56.7 | 43.3 | 1002 |
| | 17 | Male | 44.3 | 55.7 | 1033 |
| | | Female | 41.0 | 59.0 | 1069 |
| 81-82 | 13 | Male | 51.9 | 48.1 | 935 |
| | | Female | 46.6 | 53.4 | 862 |
| | 17 | Male | 43.8 | 56.2 | 958 |
| | | Female | 39.9 | 60.1 | 1011 |

again, that between age and the math factor. It accounted for over two-thirds of the variation in the model. Assessment year was the next strongest relationship, accounting for just over 12% of the variation. Gender differences accounted for an additional 8% of the variation. There was also a significant interaction between age and assessment year which accounted for 9% of the variation. If all of these significant terms were included in the model, one could achieve almost prefect prediction, since the model would account for almost 100% of the variation. However, since one of the goals of log-linear analysis is parsimony, the object is to see how many terms can be eliminated and still give a reasonably good prediction of the dependent

variable. The final model (Model H6 in Table 13) included the direct effects of age and assessment year, and accounted for over 82% of the variation in the model.

TABLE 13

Multivariate Model of Math as a Discipline Factor, Gender, Age, and Year

| Model | Terms | d.f. | L.R.$X^2$ | CMPD |
|---|---|---|---|---|
| H1 | GAY,M. | 7 | 169.96 | -- |
| H2 | GAY,MA,MY,MG. | 4 | 15.66 | .908 |
| H3 | Difference due to MA. | 1 | 115.79 | .681 |
| H4 | Difference due to MY. | 1 | 20.83 | .123 |
| H5 | Difference due to MG. | 1 | 14.15 | .083 |
| H6 | GAY,MA,MY. | 5 | 29.81 | .825 |

Legend:
M = Math as a Discipline Factor.
G = Gender.
A = Age.
Y = Year of assessment.
d.f. = Degrees of Freedom.
L.R.$X^2$ = Likelihood-Ratio Chi-Square.
CMPD = Coefficient of Multiple-Partial Determination.

Standardized values for these terms are included in Table 14. Students who were 17-years-old were more likely than 13-year-old students to be ranked "high" on the Math as a Discipline factor. Students assessed in 1981-82 were also more likely to be rated "high" on this factor.

TABLE 14

Significant Relationships Between Math as a Discipline Factor, Gender, Age, and Year

| | Math as a Discipline | | |
|---|---|---|---|
| | Low | High | N |
| Age | | | |
| 13-year-olds | 10.51 | -10.51 | 3858 |
| 17-year-olds | -10.51 | 10.51 | 4070 |
| Year of Assessment | | | |
| 1977-1978 | 4.64 | -4.64 | 4162 |
| 1981-1982 | -4.64 | 4.64 | 3766 |

The third factor identified was titled Math as a Process, and it included the following items:

There is always a rule to follow in solving math.

Math requires practice in following rules.

Knowing why an answer is correct is as important as the correct answer.

Knowing how to solve is as important as solution.

Positive responses to these items were "strongly disagree" or "disagree" to the first two, and "strongly agree" or "agree" to the last two. Those who had two or more positive responses were classified as "high" on the Mathematics as a Process factor. All others were classified as "low." The multivariate distribution for this factor is presented in Table 15.

TABLE 15

Multivariate Distribution of Math as a Process Factor

| Year | Age | Gender | Math as a Process: Low | Math as a Process: High | N |
|---|---|---|---|---|---|
| 77-78 | 13 | Male | 17.2 | 82.8 | 1060 |
| | | Female | 14.2 | 85.8 | 1001 |
| | 17 | Male | 10.8 | 89.2 | 1033 |
| | | Female | 9.9 | 90.1 | 1068 |
| 81-82 | 13 | Male | 17.5 | 82.5 | 936 |
| | | Female | 13.2 | 86.8 | 861 |
| | 17 | Male | 14.1 | 85.9 | 958 |
| | | Female | 8.7 | 91.3 | 1012 |

The logit analysis showed that age was the strongest predictor, accounting for almost 59% of the variation (see Table 16). Gender was the next strongest predictor and it accounted for almost 30% of the variation. The inclusion of these two significant effects resulted in a final model which accounted for over 90% of the variation. This provided a very good fit to the data.

Examination of the Standardized Values for these two terms showed that 17-year-olds were more likely to be ranked "high" on this factor. Females were more likely than males to be ranked "high" on this factor (see Table 17).

The final factor identified was called Math in Daily Life. It included the following items:

Math is useful in solving everyday problems.

TABLE 16

Multivariate Model of Math as a Process Factor, Gender, Age, and Year

| Model | Terms | d.f. | L.R.$X^2$ | CMPD |
|---|---|---|---|---|
| H1 | GAY,M. | 7 | 64.93 | -- |
| H2 | GAY,MA,MY,MG. | 4 | 6.01 | .907 |
| H3 | Difference due to MA. | 1 | 38.07 | .586 |
| H4 | Difference due to MG. | 1 | 19.25 | .296 |
| H5 | Difference due to MY. | 1 | 0.23 | .004 |
| H6 | GAY,MA,MG. | 5 | 6.24 | .904 |

Legend:
M = Math as a Process Factor.
G = Gender.
A = Age.
Y = Year of assessment.
d.f. = Degrees of Freedom.
L.R.$X^2$ = Likelihood-Ratio Chi-Square.
CMPD = Coefficient of Multiple-Partial Determination.

TABLE 17

Significant Relationships Between Math as a Process Factor, Gender, Age, and Year

| | Math as a Process | | |
|---|---|---|---|
| | Low | High | N |
| Age | | | |
| 13-year-olds | 6.13 | -6.13 | 3858 |
| 17-year-olds | -6.13 | 6.13 | 4070 |
| Gender | | | |
| Male | 4.37 | -4.37 | 3986 |
| Female | -4.37 | 4.37 | 3942 |

Most of math has practical use.

A person can get along well without using math.

Positive responses to these items were "strongly agree" or "agree" to the first two, and "strongly disagree" or "disagree" to the third statement. Those who with a positive response to all three statements were rated as "high" on this factor. All others were rated as "low." The multivariate distribution is presented in Table 18.

TABLE 18

Multivariate Distribution of Math in Daily Life Factor

| | | | Math in Daily Life | | |
|---|---|---|---|---|---|
| Year | Age | Gender | Low | High | N |
| 77-78 | 13 | Male | 41.9 | 58.1 | 1060 |
| | | Female | 38.8 | 61.2 | 1001 |
| | 17 | Male | 42.8 | 57.2 | 1033 |
| | | Female | 45.4 | 54.6 | 1069 |
| 81-82 | 13 | Male | 41.7 | 58.3 | 936 |
| | | Female | 40.1 | 59.9 | 862 |
| | 17 | Male | 44.7 | 55.3 | 958 |
| | | Female | 46.6 | 53.4 | 1011 |

The logit analysis is shown in Table 19. As in the first three factors, age was the strongest predictor in the model, accounting for almost 71% of the variation. Assessment year accounted for an additional 5% (see Table 19).

There was no gender relationship. The final model included only the effect of age, and accounted for just over 71% of the variation, a reasonably good fit for the data.

TABLE 19

Multivariate Model of Math in Daily Life Factor, Gender, Age, and Year

| Model | Terms | d.f. | L.R.$X^2$ | CMPD |
|---|---|---|---|---|
| H1 | GAY,M. | 7 | 20.19 | -- |
| H2 | GAY,MA,MY,MG. | 4 | 4.85 | .760 |
| H3 | Difference due to MA. | 1 | 14.27 | .707 |
| H4 | Difference due to MY. | 1 | 0.94 | .047 |
| H5 | Difference due to MG. | 1 | 0.00 | .000 |
| H6 | GAY,MA. | 6 | 5.79 | .713 |

Legend:
M = Math in Daily Life Factor.
G = Gender.
A = Age.
Y = Year of assessment.
d.f. = Degrees of Freedom.
L.R.$X^2$ = Likelihood-Ratio Chi-Square.
CMPD = Coefficient of Multiple-Partial Determination.

Table 20 shows that 13-year-olds were more likely to be rated "high" on this factor than were 17-year-olds.

In summary, it can be stated that gender differences accounted for about 46% of the variation in the multivariate model of the Positive Math Attitudes Index. The other independent variables were year, which accounted for an addi-

TABLE 20

Significant Relationships Between Math in Daily Life Factor, Gender, Age, and Year

| | Math in Daily Life | | |
|---|---|---|---|
| | Low | High | N |
| Age | | | |
| 13-year-olds | -3.79 | 3.79 | 3858 |
| 17-year-olds | 3.79 | -3.79 | 4070 |

tional 23% and age, which accounted for 11%. Females were more likely than males to be rated "moderate" or "high" on the PMAI. Students assessed in 1981-1982 were more likely to be rated "high" than were those assessed in 1977-1978.

The analyses of the four mathematics attitudes factors identified showed that age was the strongest predictor for each of the individual factors. Thirteen-year-old students were more likely than 17-year-olds to be rated as "high" on the Math and Oneself and the Math in Daily Life factors. Seventeen-year-old students were more likely to be rated "high" on the Math as a Discipline and the Math as a Process factors.

Gender differences also made a significant contribution to the prediction of the Mathematics and Oneself factor and the Mathematics as a Process factor. Females were more likely than males to be rated as "high" on both of these factors.

## 3. MATHEMATICS ACHIEVEMENT

The analysis of mathematics achievement was done using the ANOVA procedure in SPSS-X. The dependent variable used was the percentile ranking of the individual's mathematics achievement score. The independent variables used were the Positive Math Attitudes Index, race of the respondent, type of community, gender, and the school racial balance.

The percentile ranking on achievement was calculated using the percentage correct score. Using the documentation supplied by NAEP, the exercise items were recoded into "correct," "incorrect," or "missing." The achievement of the respondent for each individual booklet was computer-calculated by dividing the number of correct responses by the total number of exercises attempted in the booklet. Exercises coded as "missing" were not included in the achievement score calculation.

Percentage scores were comparable among students who took the same exercise booklet, but not among students who took different exercise booklets as both the number of items and the level of difficulty vary from booklet to booklet. The percentage scores were then converted to percentile ranking for each assessment package. This then allowed comparison of achievement among students who responded to different booklets since scores based on percentile ranks are comparable (Mullis, 1979).

The creation of the PMAI has been previously described in this paper. The categories of racial classification used were: white, black, Hispanic, and other. These are standard racial classifications provided by NAEP.

Communities were classified according to the type of occupations reported in the Principal's Questionnaire. Each principal was asked to indicate what proportion of the community was employed in professional, skilled trades, unskilled labor, or farm occupations, along with the proportion who were unemployed or on welfare. The total of these six categories for each community was 100%.

Those communities with over 50% employment in professional occupations were classified as "mainly professional." Those with over 50% in skilled trades were classified as "mainly skilled labor." Those with over 50% in unskilled labor occupations were classified as "mainly unskilled labor." Those with over 50% in farm occupations were classified as "mainly farming." Those with over 50% unemployed were classified as "mainly unemployed." Those with over 50% on welfare were classified as "mainly welfare." The remaining were classified as "mixed."

This "mixed" category was then further divided. If the proportion of professional and skilled workers was over 50%, the community was classified as "professional-skilled." If the proportion of unemployed and welfare was over 50%, the

community was classified as "unemployed-welfare." If the proportion of unskilled workers and farm occupations was over 50%, the community was classified as "unskilled-farm." All others remained classified as "mixed." The "unemployed-welfare" classification and the "unskilled-farm" classification were then combined for this analysis to give a total of three types of communities: those that have no predominant category, those in which over 50% of the people are employed in professional or skilled occupations, and those in which over 50% of the people are unemployed or on welfare, or in which over 50% were employed in unskilled or farm occupations.

Schools were also classified according to the racial composition of the school, using information provided on the Principal's Questionnaire. Principals were asked to indicate what proportion of the student body was white. The categories used were: 39% or less, 40% to 69%, and 70% and over. These categories were named mostly non-white, mixed, and mostly white, respectively.

The means for percentile rankings on mathematics achievement are shown in Table 21. There appear to be significant differences among each of the independent variable categories.

A five-way analysis of variance confirmed that each of these main effects was significantly different at or beyond

TABLE 21

Mean Percentile Ranking on Math Achievement for Main Effects

| Group | Mean | Std. Dev. | N |
|---|---|---|---|
| Positive Math Attitude Index | | | |
| Low | 41.0459 | 27.3845 | 2923 |
| Moderate | 51.2810 | 28.0862 | 2590 |
| High | 64.2841 | 26.4103 | 2415 |
| Race of Respondent | | | |
| White | 56.6658 | 27.3614 | 6310 |
| Black | 26.3055 | 22.6247 | 1083 |
| Spanish Heritage | 34.8949 | 26.4169 | 410 |
| Other | 61.2761 | 26.7083 | 126 |
| Type of Community | | | |
| Mixed occupations | 45.4588 | 28.3205 | 2568 |
| Primarily Professional or skilled occupations | 59.8454 | 27.9207 | 3338 |
| Primarily Unskilled-Farm or Unemployed-Welfare | 45.2729 | 27.8428 | 2023 |
| Gender | | | |
| Male | 53.0143 | 29.5629 | 3985 |
| Female | 49.9046 | 28.1807 | 3943 |
| Racial Balance of School | | | |
| Mostly non-white | 31.9127 | 27.0322 | 798 |
| Mixed | 44.4594 | 28.1931 | 1460 |
| Mostly white | 56.0241 | 27.8436 | 5670 |

the .001 level. The results of this analysis are presented in Table 22.

Inspection of the means reported in Table 21 reveals that students rated as "high" on the PMAI were more likely to have a higher percentile ranking than students in either of the other two categories.

Students classified as "other" in racial classification were ranked highest on mathematics achievement. Those who were classified as "white" were next highest on mathematics achievement. Third ranking on mathematics achievement among the racial classifications were those classified as "Hispanics." Blacks were the lowest on mathematics achievement.

TABLE 22

Analysis of Variance for Math Achievement

| Source of Variation | df | F | Sign. of F |
|---|---|---|---|
| Main Effects | 10 | 293.073 | 0.001 |
| Positive Math Attitude Index | 2 | 455.801 | 0.001 |
| Race of Respondent | 3 | 229.047 | 0.001 |
| Type of Community | 2 | 148.002 | 0.001 |
| Gender | 1 | 36.928 | 0.001 |
| School Race | 2 | 9.157 | 0.001 |
| Two-way Interactions | 39 | 1.574 | 0.013 |
| PMAI x Respondent Race | 6 | 2.051 | 0.055 |
| PMAI x Type of Community | 4 | 1.350 | 0.249 |
| PMAI x Gender | 2 | 3.190 | 0.041 |
| PMAI x School Race | 4 | 2.512 | 0.040 |
| Respondent Race x Type of Community | 6 | 0.622 | 0.713 |
| Respondent Race x Gender | 3 | 0.196 | 0.899 |
| Respondent Race x School Race | 6 | 0.478 | 0.825 |
| Type of Community x Gender | 2 | 0.944 | 0.389 |
| Type of Community x School Race | 4 | 4.490 | 0.001 |
| Gender x School Race | 2 | 1.034 | 0.356 |

Students who lived in communities in which the majority of people were employed in professional or skilled occupations were more likely to be ranked higher on mathematics

achievement than were students who lived in either of the other two types of communities.

Males were more likely to be ranked higher on mathematics achievement than were females.

Students who attended schools that were mostly white in racial composition were most likely to be ranked higher on mathematics achievement. Those who attended schools that were mostly non-white were most likely to be ranked lowest on mathematics achievement.

There were three significant two-way interactions identified (see Table 22). The first was that between type of community and racial balance of the school. Means for all the two-way interactions are presented in Table 23.

Students who attended schools that were mostly white and who lived in communities in which the majority of the people were employed in professional or skilled occupations were most likely to score higher on mathematics achievement. Those who attended schools that were mostly non-white and who lived in communities in which the majority of people were either unemployed or on welfare, or were employed in unskilled or farming occupations were more likely to score lower on mathematiCs achievement.

The second two-way interaction was that between gender and math attitudes. The differences in mean percentile ranking were greater between males and females who were rated as "high" on the PMAI.

TABLE 23

Mean Percentile Ranking on Math Achievement for Interaction Effects

| Group | | Mean | Std. Dev. | N |
|---|---|---|---|---|
| Low PMAI | x White | 46.4290 | 26.5383 | 2241 |
| Low PMAI | x Black | 19.7578 | 19.0708 | 467 |
| Low PMAI | x Hispanic | 25.9338 | 23.5468 | 173 |
| Low PMAI | x Other | 53.2664 | 25.3808 | 42 |
| Mod PMAI | x White | 56.6445 | 26.4661 | 2009 |
| Mod PMAI | x Black | 27.8714 | 22.6991 | 393 |
| Mod PMAI | x Hispanic | 36.6428 | 24.8364 | 143 |
| Mod PMAI | x Other | 63.1155 | 28.6582 | 44 |
| High PMAI | x White | 67.8256 | 24.6165 | 2060 |
| High PMAI | x Black | 37.3348 | 24.6248 | 222 |
| High PMAI | x Hispanic | 48.8047 | 27.4362 | 94 |
| High PMAI | x Other | 67.5537 | 24.2836 | 40 |
| Low PMAI | x Mixed Occup. | 36.2365 | 25.8795 | 988 |
| Low PMAI | x Prof-Skill | 48.8289 | 27.6309 | 1168 |
| Low PMAI | x Other Mix | 35.3931 | 26.0835 | 767 |
| Mod PMAI | x Mixed Occup. | 44.3130 | 27.6277 | 877 |
| Mod PMAI | x Prof-Skill | 61.1188 | 26.3864 | 1056 |
| Mod PMAI | x Other Mix | 44.7660 | 26.6660 | 657 |
| High PMAI | x Mixed Occup. | 59.8495 | 26.6452 | 703 |
| High PMAI | x Prof-Skill | 70.1920 | 25.3136 | 1114 |
| High PMAI | x Other Mix | 58.4991 | 25.8671 | 598 |
| Low PMAI | x Male | 42.3463 | 28.0325 | 1575 |
| Low PMAI | x Female | 39.5263 | 26.5369 | 1348 |
| Mod PMAI | x Male | 52.8689 | 28.7187 | 1238 |
| Mod PMAI | x Female | 49.8266 | 27.4242 | 1352 |
| High PMAI | x Male | 67.5079 | 26.1259 | 1172 |
| High PMAI | x Female | 61.2447 | 26.3268 | 1243 |

TABLE 23

Mean Percentile Ranking on Math Achievement for Interaction Effects

| Group | | Mean | Std. Dev. | N |
|---|---|---|---|---|
| Low PMAI | x Mostly Non-White | 23.1372 | 22.8449 | 327 |
| Low PMAI | x Mixed Race | 36.9213 | 27.2454 | 579 |
| Low PMAI | x Mostly white | 45.1293 | 26.7607 | 2018 |
| Mod PMAI | x Mostly Non-White | 30.9463 | 25.0071 | 281 |
| Mod PMAI | x Mixed Race | 43.7485 | 26.7082 | 509 |
| Mod PMAI | x Mostly white | 56.5810 | 26.9774 | 1800 |
| High PMAI | x Mostly Non-White | 48.3776 | 29.0881 | 191 |
| High PMAI | x Mixed Race | 57.1709 | 27.2247 | 372 |
| High PMAI | x Mostly white | 67.3486 | 25.0737 | 1852 |
| White | x Mixed Occup. | 52.1019 | 27.0917 | 1868 |
| White | x Prof-Skill | 62.2913 | 26.9132 | 2905 |
| White | x Other Mix | 51.5792 | 26.5026 | 1537 |
| Black | x Mixed Occup. | 24.5357 | 21.4858 | 514 |
| Black | x Prof-Skill | 34.5501 | 26.3775 | 243 |
| Black | x Other Mix | 22.9626 | 19.7682 | 326 |
| Hispanic | x Mixed Occup. | 32.8120 | 25.4452 | 151 |
| Hispanic | x Prof-Skill | 46.7255 | 27.3154 | 126 |
| Hispanic | x Other Mix | 26.0360 | 22.4104 | 132 |
| Other | x Mixed Occup. | 53.0601 | 24.8061 | 34 |
| Other | x Prof-Skill | 70.4708 | 23.5239 | 64 |
| Other | x Other Mix | 50.0564 | 29.1705 | 27 |
| White | x Male | 57.8663 | 28.0012 | 3220 |
| White | x Female | 55.4145 | 26.6251 | 3090 |
| Black | x Male | 26.5347 | 23.7116 | 489 |
| Black | x Female | 26.1167 | 21.7071 | 594 |
| Hispanic | x Male | 37.0603 | 27.8359 | 209 |
| Hispanic | x Female | 32.6317 | 24.7144 | 200 |
| Other | x Male | 62.9822 | 25.7658 | 67 |
| Other | x Female | 59.3565 | 27.8256 | 59 |

TABLE 23

Mean Percentile Ranking on Math Achievement for Interaction Effects

| Group | | Mean | Std. Dev. | N |
|---|---|---|---|---|
| White | x Mostly Non-White | 50.7180 | 29.6285 | 152 |
| White | x Mixed Race | 52.7000 | 27.0856 | 917 |
| White | x Mostly white | 57.5316 | 27.2638 | 5241 |
| Black | x Mostly Non-White | 24.3373 | 22.2741 | 438 |
| Black | x Mixed Race | 26.0150 | 21.3463 | 385 |
| Black | x Mostly white | 30.0685 | 24.6044 | 259 |
| Hispanic | x Mostly Non-White | 26.9422 | 22.9256 | 157 |
| Hispanic | x Mixed Race | 38.4019 | 26.2862 | 135 |
| Hispanic | x Mostly white | 41.4722 | 28.3673 | 118 |
| Other | x Mostly Non-White | 56.4428 | 27.5227 | 51 |
| Other | x Mixed Race | 60.4135 | 26.9701 | 23 |
| Other | x Mostly white | 66.4136 | 25.3226 | 52 |
| Mixed Occup. | x Male | 46.8233 | 28.8512 | 1297 |
| Mixed Occup. | x Female | 44.0653 | 27.7102 | 1271 |
| Prof-Skill | x Male | 62.0569 | 28.1952 | 1633 |
| Prof-Skill | x Female | 57.7256 | 27.4968 | 1704 |
| Other Mix | x Male | 46.6232 | 28.8845 | 1054 |
| Other Mix | x Female | 43.8024 | 26.5992 | 968 |
| Mixed Occup. | x Mostly Non-White | 28.4508 | 25.9098 | 285 |
| Mixed Occup. | x Mixed Race | 41.1391 | 27.0416 | 809 |
| Mixed Occup. | x Mostly white | 51.1185 | 27.7297 | 1474 |
| Prof-Skill | x Mostly Non-White | 52.3775 | 26.6592 | 125 |
| Prof-Skill | x Mixed Race | 55.1056 | 28.9858 | 410 |
| Prof-Skill | x Mostly white | 60.8728 | 27.7036 | 2802 |
| Other Mix | x Mostly Non-White | 27.8411 | 24.9680 | 388 |
| Other Mix | x Mixed Race | 37.4964 | 25.6696 | 241 |
| Other Mix | x Mostly white | 51.4637 | 26.5544 | 1394 |
| Male | x Mostly Non-White | 33.5180 | 28.6697 | 369 |
| Male | x Mixed Race | 45.2782 | 29.0773 | 725 |
| Male | x Mostly white | 57.4436 | 28.3752 | 2891 |
| Female | x Mostly Non-White | 30.5313 | 25.4924 | 429 |
| Female | x Mixed Race | 43.6512 | 27.2879 | 735 |
| Female | x Mostly white | 54.5475 | 27.2062 | 2779 |

The third significant two-way interaction was that between racial balance of the school and math attitudes. Students who attended schools that were mostly white and who ranked "high" on the PMAI were most likely to be rated highest on achievement. Those who attended schools that were mostly non-white and who ranked "low" on the PMAI were most likely to be lower on mathematics achievement.

Based on this five-way analysis of variance, it can be concluded that gender differences in mathematics achievement do exist. Males score higher on mathematics assessments than do females. However, the differences between males and females are less than the differences between the categories of the other variables examined. Additional studies need to be done to further explore the relationships between these other variables, gender, and mathematics achievement.

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